CEMENT AND LIME MANUFACTURE

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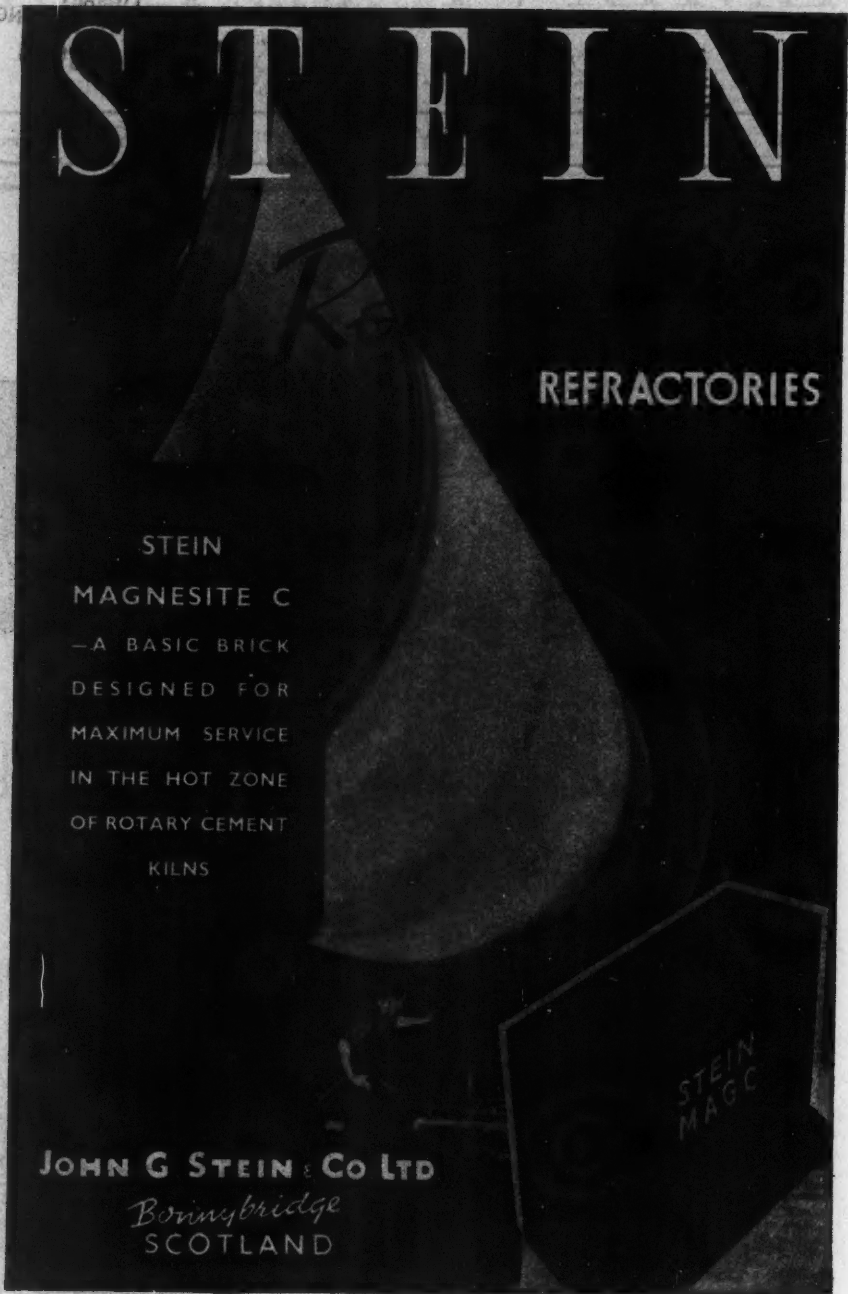
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The Rate of Development of the Compressive Strength of Concrete.

By W. E. ABBOTT, M.Sc., F.R.I.C.

THE characteristic of the development of the compressive strength of concrete is a high initial rate of increase that decreases rapidly to a slower and steadily decreasing rate. In some circumstances a small increase of strength is observed after more than one year.

Data are given in Road Note No. 4, "The Design of Concrete Mixes," and Road Research Technical Paper No. 5 (second edition), both of which were published recently by the Road Research Laboratory, showing the relation between the crushing strength and age of concrete made with ordinary and rapid-hardening Portland cements and having different water-cement ratios. The rate of development of the compressive strength of concrete as indicated by this data has been expressed mathematically by the writer in "Concrete and Constructional Engineering," June, 1948, in the following manner.

The strength y developed in T days can be divided into two components y_1 and y_2 such that $y_1 + y_2 = y$. The formulæ $\log \dfrac{3{,}500}{3{,}500 - y_1} = 0{\cdot}08T$ and $\log \dfrac{4{,}200}{4{,}200 - y_2} = 0{\cdot}002T$ apply to ordinary Portland cement concrete having a water-cement ratio of 0·6. Table I shows the close agreement between the calculated and observed strengths. Since the formulæ are monomolecular in type, the conclusion was drawn that the development of strength proceeds as if it were the result of two independent and concurrent monomolecular reactions. The values of the coefficients by which T is multiplied vary considerably, but one is always much greater than the other. The general relationship can be expressed as $y = c_1 (1 - e^{-K_1T}) + c_2(1 - e^{-K_2T})$, where c_1 is the total compressive strength produced by one reaction and c_2 is that produced by the other reaction. In the example c_1 and c_2 are 3,500 lb. and 4,200 lb. per square inch respectively. Complicated

reactions are for no obvious reason rather surprisingly represented by monomolecular equations. The writer suggested that further examination might reveal that the faster and slower reactions are due to the hydration of tricalcium-silicate and dicalcium-silicate respectively.

TABLE I.—ORDINARY PORTLAND CEMENT CONCRETE. WATER-CEMENT RATIO : 0·6.

Number of days (T)	Compressive strength in lb. per square inch			
	y_1	y_2	$y_1 + y_2 = y$	Observed
3	1,490	60	1,550	1,500
7	2,540	130	2,670	2,600
28	3,480	510	3,990	4,000
90	3,500	1,430	4,930	5,000
365	3,500	3,420	6,920	7,000

In the following this consideration is presented in a slightly different manner and is extended to other types of cement. The symbols have the significations that follow :

c_1, the compressive strength ultimately attained due to the faster reaction ; the probable value is selected after calculation.
c_2, the corresponding strength due to the slower reaction.
K_1, the coefficient for the faster reaction.
K_2, the coefficient for the slower reaction.
y_1, the strength due to the faster reaction in T days.
y_2, the strength due to the slower reaction in T days.
$y = y_1 + y_2$, the combined compressive strength developed in T days.

For ordinary Portland cement concrete c_1, K_1, and y_1 are related by

$$\log \frac{c_1}{c_1 - y_1} = K_1 T \quad \text{.. .. ..} \quad (1a)$$

and c_2, K_2 and y_2 by

$$\log \frac{c_2}{c_2 - y_2} = K_2 T \quad \text{.. .. ..} \quad (1b)$$

The expression for y requires modifying, as discussed later, for rapid-hardening Portland cement concrete. All data refer to 1 : 2 : 4 concretes. All logarithms are to the base of 10.

Ordinary Portland Cement Concrete.

As an example, the rate of development of compressive strength in lb. per square inch of ordinary Portland cement concrete with a water-cement ratio of 0·45 is as follows :

At 3 days : y_1 = 2610 ; y_2 = 70 ; $y = y_1 + y_2$ = 2680 ; observed = 2700.
At 7 „ „ = 4210 ; „ = 160 ; „ = $y_1 + y_2$ = 4370 ; „ = 4300.
At 28 „ „ = 5290 ; „ = 610 ; „ = $y_1 + y_2$ = 5900 ; „ = 6000.
At 90 „ „ = 5300 ; „ = 1690 ; „ = $y_1 + y_2$ = 6990 ; „ = 7000.
At 365 „ „ = 5300 ; „ = 3980 ; „ = $y_1 + y_2$ = 9280 ; „ = 9300.

y_1 is calculated on the assumption that c_1 and K_1 are 5,300 lb. per square inch and 0·098 respectively, and y_2 on the assumption that c_2 and K_2 are 4,800 lb. per square inch and 0·0021 respectively.

Formulæ (*1a*) and (*1b*) are identical in type and, as previously stated, are monomolecular, that is the strength of each component increases as if it were proportional to the amount of the products of a monomolecular reaction. In other words, the rate of development of the compressive strength is consistent with the strength being due to the progress of two independent and concurrent monomolecular reactions.

Similar values of the various symbols can be derived for different water-cement ratios. The coefficient K_1 is always much greater than K_2. Although the coefficients and component strengths for each water-cement ratio were derived independently, it is seen from the following that the values of c_1, c_2, K_1, and K_2 vary in a regular manner.

Water-cement ratio 0·35 :	K_1 = 0·11 ;	K_2 = 0·0020 ;	c_1 = 7000 ;	c_2 = 5000.
,, ,, 0·40 :	,, = 0·11 ;	,, = 0·0021 ;	,, = 6000 ;	,, = 5000.
,, ,, 0·45 :	,, = 0·098 ;	,, = 0·0021 ;	,, = 5300 ;	,, = 4800.
,, ,, 0·50 :	,, = 0·09 ;	,, = 0·0020 ;	,, = 4700 ;	,, = 4600.
,, ,, 0·55 :	,, = 0·084 ;	,, = 0·0021 ;	,, = 4100 ;	,, = 4300.
,, ,, 0·60 :	,, = 0·08 ;	,, = 0·0022 ;	,, = 3500 ;	,, = 4000.
,, ,, 0·65 :	,, = 0·07 ;	,, = 0·0025 ;	,, = 3100 ;	,, = 3600.
,, ,, 0·70 :	,, = 0·06 ;	,, = 0·0029 ;	,, = 2600 ;	,, = 3200.
,, ,, 0·75 :	,, = 0·062 ;	,, = 0·0030 ;	,, = 2300 ;	,, = 2900.
,, ,, 0·80 :	,, = 0·059 ;	,, = 0·0030 ;	,, = 2100 ;	,, = 2400.

The component strengths c_1 and c_2 decrease as the water-cement ratio increases. The coefficient K_1 of the faster reaction decreases but K_2, that of the slower reaction, increases as the water-cement ratio increases.

Rapid-hardening Portland Cement Concrete.

The data in Road Paper No. 4 relating to rapid-hardening Portland cement concrete can be treated in the same way as the data for ordinary Portland cement concrete, but the calculated and observed strengths do not agree with similar precision. If, however, it be assumed that a third reaction operates up to the end of the third day the agreement is considerably improved. Taking the case where the water-cement ratio is 0·5 and deducting 1,850 lb. per square inch from each compressive strength the residual strengths can be represented in the manner described for ordinary Portland cement concrete. This means that the compressive strength $y = 1850 + y_1 + y_2$, or if the term corresponding to 1850 is indicated by Y, the compressive strength in T days is $y = Y + y_1 + y_2$. The strengths derived when, with a water-cement ratio of 0·5, c_1, c_2, K_1, and K_2 are 3600 lb., 3000 lb., 0·078, and 0·0038 respectively, are as follows :

At 3 days :	y_1=1500 ;	y_2= 80 ;	$y = 1850 + y_1 + y_2$ = 3430 ;	observed = 3400.
At 7 ,,	,, =2570 ;	,, = 180 ;	,, =4600 ;	,, =4600.
At 28 ,,	,, =3580 ;	,, = 650 ;	,, =6080 ;	,, =6200.
At 90 ,,	,, =3600 ;	,, =1640 ;	,, =7090 ;	,, =7000.
At 365 ,,	,, =3600 ;	,, =2870 ;	,, =8320 ;	,, =8400.

There is no reason for believing that the component Y differs in anything but speed from the other two. Assuming this to be so it may be said that strength of rapid-hardening Portland cement concrete increases as if the products of three separate and concurrent monomolecular reactions contribute to it. In the following

the values of the symbols calculated for some of the data relating to rapid-hardening Portland cement in Table 2 of Road Note No. 4 are summarised.

Water-cement ratio 0·35 :	Y = 3000 ;	K_1 = 0·090 ;	K_2 = 0·0030 ;	c_1 = 5100 ;	c_2 = 3100
,, ,, 0·40 :	,, = 2600 ;	,, = 0·085 ;	,, = 0·0026 ;	,, = 4500 ;	,, = 3100.
,, ,, 0·45 :	,, = 2200 ;	,, = 0·087 ;	,, = 0·0036 ;	,, = 4000 ;	,, = 3200.
,, ,, 0·50 :	,, = 1850 ;	,, = 0·078 ;	,, = 0·0038 ;	,, = 3600 ;	,, = 3000.
,, ,, 0·55 :	,, = 1600 ;	,, = 0·073 ;	,, = 0·0039 ;	,, = 3200 ;	,, = 3000.
,, ,, 0·60 :	,, = 1400 ;	,, = 0·065 ;	,, = 0·0039 ;	,, = 2800 ;	,, = 3000.
,, ,, 0·75 :	,, = 600 ;	,, = 0·072 ;	,, = 0·0039 ;	,, = 2300 ;	,, = 2200.

High-alumina Cement.

Data given in " The Characteristics of Ciment Fondu " of the rate of development of the compressive strength of 1 : 2 : 4 high-alumina cement concrete having a water-cement ratio of 0·6 show that there is a lag of about four hours before the really rapid development of strength commences. With the symbols defined in the foregoing the phenomena can be represented by the two concurrent formulæ :

$$\log \frac{3200}{3200 - y_1} = 0{\cdot}08T \quad \ldots \quad (2a)$$

$$\text{and } \log \frac{7000}{7000 - y_2} = 1{\cdot}5(T - 0{\cdot}16) \quad \ldots \quad (2b)$$

Formula (2*a*) is similar to (1*a*), and (2*b*) is the same type except that $(T - 0{\cdot}16)$ is substituted for T, the physical significance of this being that the reaction represented by (2*b*) becomes effective 0·16 day (that is about four hours) after the start of the reaction represented by (2*a*). The following shows that the compressive strength $y = y_1 + y_2$ calculated from (2*a*) and (2*b*) is close to the observed strengths (in lb. per square inch).

At 6 hours :	y_1 = 140 ;	y_2 = 1870 ;	$y = y_1 + y_2$ = 2010 ;	observed = 2000.
At 12 ,,	,, = 280 ;	,, = 4840 ;	,, = 5120 ;	,, = 5500.
At 18 ,,	,, = 410 ;	,, = 6090 ;	,, = 6500 ;	,, = 6500.
At 1 day :	,, = 540 ;	,, = 6610 ;	,, = 7150 ;	,, = 7000.
At 3 days :	,, = 1360 ;	,, = 7000 ;	,, = 8360 ;	,, = 8400.
At 7 ,,	,, = 2320 ;	,, = 7000 ;	,, = 9320 ;	,, = 9300.
At 28 ,,	,, = 3180 ;	,, = 7000 ;	,, = 10,180 ;	,, = 10,000.
At 90 ,,	,, = 3200 ;	,, = 7000 ;	,, = 10,200 ;	,, = 10,500.

Again one coefficient is much greater than the other (about 19 times in this instance), but the coefficient of the slower reaction has about the same magnitude as that of the faster reaction in ordinary Portland cement concrete. Such a result might have been expected from the known characteristics of the two cements.

If the hypothesis suggested in this article is correct, one would expect the increase in strength of a pure cement compound to be represented by a single formula of the same type as (1*a*) or (1*b*). Mr. Bogue and Mr. Lerch (J. Ind. Eng. Chem. 26, 837, 1934) made $\frac{15}{16}$ in. by 1 in. cylinders of the cement compounds and tested them at intervals during a period of two years. Calculation shows that the small specimens prepared with $\beta 2CaO.SiO_2$, to which 5 per cent. of gypsum had been added, gained strength approximately in accordance with a single formula of the type of (1*a*), that is,

$$\log \frac{13{,}000}{13{,}000 - y} = 0{\cdot}0018T \quad \ldots \quad (3)$$

In the following the compressive strengths (in lb. per square inch) calculated from formula (3) are compared with the observed strengths, and except at early ages the agreement is good.

At 7 days :	y (calculated from formula 3)	= 380 ;	observed =	220.
At 28 ,,	y ,, ,,	= 1430 ;	,, =	1200.
At 90 ,,	y ,, ,,	= 4050 ;	,, =	3900.
At 180 ,,	y ,, ,,	= 6840 ;	,, =	7700.
At 365 ,,	y ,, ,,	= 10,140 ;	,, =	9800.
At 730 ,,	y ,, ,,	= 12,370 ;	,, =	12,600.

The value of K is about the same as that for the slower reaction in ordinary Portland cement. So far as these limited results go the hypothesis is confirmed, but when the data for the other cement compounds is examined the results are erratic and no manipulation seems to give single formulæ. In the following the strengths (in lb. per square inch) of specimens made with $3CaO.SiO_2$, without gypsum, are given and are compared with those calculated on the assumption that two simultaneous reactions of the types of (1*a*) and (1*b*) are involved.

At 1 day :	y_1 = 1400 ;	y_2 = 0 ;	$y = y_1 + y_2$ = 1400 ;	observed = 1450.
At 3 days :	,, = 3300 ;	,, = 0 ;	,, = 3300 ;	,, = 2800.
At 7 ,,	,, = 5450 ;	,, = 100 ;	,, = 5550 ;	,, = 5960.
At 28 ,,	,, = 7060 ;	,, = 400 ;	,, = 7460 ;	,, = 7100.
At 90 ,,	,, = 7100 ;	,, = 1200 ;	,, = 8300 ;	,, = 7100.
At 180 ,,	,, = 7100 ;	,, = 2100 ;	,, = 9200 ;	,, = 9690.
At 365 ,,	,, = 7100 ;	,, = 3200 ;	,, = 10,300 ;	,, = 10,300.
At 730 ,,	,, = 7100 ;	,, = 4100 ;	,, = 11,200 ;	,, = 11,300.

The values of c_1, c_2, K_1 and K_2 are 7100 lb., 4500 lb., 0·09 and 0·0015 respectively, which are quite close to those already given for ordinary Portland cement. The agreement between the calculated and observed strengths is fairly close. It is seen that the observed strengths remain constant over a remarkably long period. There is a possibility that two reactions appear because the sample of $3CaO.SiO_2$ is really a mixture, but the writer is unable to assess the homogeneity of the samples of $3CaO.SiO_2$ prepared by Mr. Bogue and Mr. Lerch.

The rate of gain in strength of specimens made of pure alumina and iron-cement compounds as binders is inclined to be erratic, and the writer has failed to represent the phenomenon by a single equation.

The writer regards the results of the determination of the crushing strength of small cylinders as not always reliable. On the whole he regards the evidence given in the foregoing as not discrediting the hypothesis that cement compounds can in some way be identified with the formulæ.

Conclusions.

Monomolecular formulæ have been derived in many cases of practical chemistry, for example, in sewage disposal, where the complexity of the changes offers little hope of a physical explanation. On the other hand the fact that the hardening of cement may be attributed to the summation of the concurrent effects of two or three monomolecular formulæ may prove capable of relation to the theory that there are four cement compounds, although no doubt the fineness will affect the rates of the reactions.

It is seen that the values of K_1 and K_2 are nearly alike for concretes made from ordinary and rapid-hardening Portland cement and having the same water-cement ratio.

Small specimens made from pure $\beta 2CaO.SiO_2$ develop compressive strength as if the strength were proportional to the products of a single monomolecular reaction. Ordinary laboratory specimens of $3CaO.SiO_2$, ordinary Portland cement and high-alumina cement develop strength as if it depended on the progress of two simultaneous and separate monomolecular reactions. The data for rapid-hardening Portland cement are consistent with three concurrent and independent monomolecular reactions being involved.

Examination of the rate of gain of strength of cement or concrete may possibly aid the study of the chemistry of these materials. During tests care must be taken to ensure that the ambient temperature and other conditions affecting the rate of increase of strength are kept constant ; it is not clear, in many published results, how far these precautions have been taken.

Italian Views on the Hot Test for Soundness.

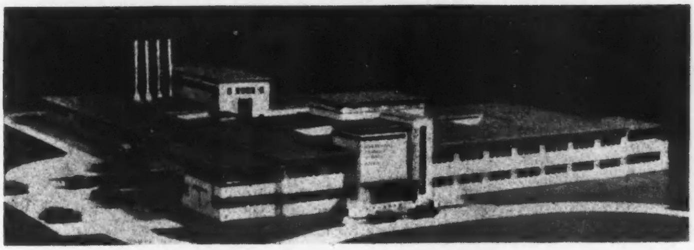
IN a recent number of "Il Cemento," Mr. Carlo Goria discusses the value of the hot test for the expansion of cement. In a series of experiments on expanding-cement mixtures, similar to those proposed by M. Lossier, it was observed that the expansive effect of the sulphate, which is experienced with specimens cured in cold water, is not always revealed by the hot test. On the contrary, by the boiling process the expansion is not revealed in the case of cement containing blastfurnace slag, and is considerably reduced in the case of cement without slag. In consequence of several experiments made under diverse conditions, an hypothesis has been formulated that agrees with the constitution which is now attributed to be the cause of the phenomenon associated with the expansion of cements.

Since the hot test of cement only reveals the presence of free lime and magnesium oxide, it is proposed by the author that a cold test for expansion, using the Le Chatelier apparatus, after curing for at least 28 days, should be reinstated in the Italian standard specifications.

New Cement Laboratory in the United States.

THE illustration is of a model of a new laboratory with a floor area of 98,000 sq. ft. to be built for the Portland Cement Association of America on a site of 15 acres near Chicago.

The basement of the main building, which is 24,931 sq. ft. in area, will contain a moist-curing room with a floor area of 81 ft. by 14 ft. and an L-shaped concrete laboratory about 1,300 sq. ft. in area where large test specimens will be made. There will be two smaller concrete laboratories for special moisture-exposure tests; in one of these a temperature of from 40 to 75 deg. F. with 100 per cent. relative humidity will be maintained. An area of 650 sq. ft. has been set aside for air storage of concrete specimens; this can be kept at 75 deg. F and 50 per cent. relative humidity. The basement will also contain the compressors and temperature apparatus for freezing and thawing tests, storage areas for test specimens, a machine shop, a mould-cleaning room, and room for storing aggregates. Space has also been reserved for air-cooling equipment which may be required later.



The first floor of the main building will contain offices, an auditorium with a seating capacity of 150 people, and a cafeteria.

The Field Research section includes a petrographic laboratory in three rooms, a dark room for developing and printing microphotographs, an instrument-repair and calibration shop, a room for work in connection with sonic vibration-testing apparatus, and a testing room 1,900 sq. ft. in area devoted exclusively to the structural development section. The equipment will include a 1,000,000-lb. compression testing machine capable of handling specimens up to 10 ft. by 40 ft., a 400,000-lb. testing machine for compressive and tensile tests, and a fatigue-testing machine for tensile, compressive, static, and impact loading tests.

The structural development room will also have equipment for making and testing expanded aggregates, a fog-room 18 ft. by 14 ft. in area where a temperature of 70 deg. F. and 100 per cent. relative humidity can be maintained, and a room which can be kept at from 65 deg. to 85 deg. F. with a relative humidity of from 25 per cent. to 75 per cent. There will also be a ball mill, a crusher, and a gas furnace, and a 15-tons overhead crane for handling heavy specimens.

The manufacturing research laboratory will be equipped with a laboratory cement kiln and chemical and physical apparatus. The applied research section

will contain a freezing and thawing room 22 ft. by 40 ft. in area, a low-temperature room which can be kept at a temperature of −20 deg. F., and a special room devoted to durability tests where temperatures can be maintained up to 100 deg F. with a humidity of 90 per cent. Adjacent to the freezing and thawing room, an L-shaped area of about 500 sq. ft. is reserved for sonic apparatus and comparators for length-change tests. Other rooms include one 22 ft. by 28 ft. in area for tests of small specimens, briquettes, etc., a moisture-curing room 17 ft. by 16 ft. in area, an autoclave room measuring 6 ft. by 16 ft., and a physical testing room containing one 400,000-lb. and two 75,000-lb. compression-testing machines and equipment for testing briquettes. One of the applied research laboratories will be equipped to reach a temperature of 130 deg. F. with 25 per cent. to 35 per cent. relative humidity.

The second floor of the main building will be occupied by the basic research section, a transportation development laboratory, a general chemical laboratory for the applied research section, a drawing office, an office-supply room, a filing, typing, mimeographing and mailing room, a number of special laboratories, and about 20 offices. This section will include a colloidal chemistry laboratory with a floor area of 23 ft. by 22 ft. in which the temperature will be kept at 73 deg. F. Another room (22 ft. by 13 ft.), to be kept at the same temperature, will contain X-ray and optical apparatus. There will also be an electron microscope. The general physics laboratory will be maintained at a temperature of 73 deg. F. The physical chemistry laboratory will be adjacent to an electronics laboratory, with space reserved for expansion.

The main room of the transportation development laboratory will be 55 ft. by 36 ft. in area, and will adjoin a small laboratory of 20 ft. by 40 ft. Equipment for this laboratory will include a 90,000-lb. compression and various smaller testing machines. The large laboratory will also include an oven-room 13 ft. by 10 ft., with ventilating louvres ; this will be used for treating and testing soils. There will also be a low-temperature room (8 ft. by 10 ft.) to be kept at −20 deg. F., and an 8-ft. by 10-ft. fog-room to be maintained at a temperature of 70 to 75 deg. F. and 100 per cent. relative humidity. Another small room will have atmospheric control from 30 per cent. to 98 per cent. relative humidity. The drawing office will be 19 ft. by 10 ft. in area and will adjoin a dark room and a room containing planographing and osloid-print reproduction equipment. The office-supply room (12 ft. by 24 ft.) will adjoin a room 39 ft. by 22 ft. reserved for filing, typing, mimeographing and mailing.

The general chemistry laboratory in the applied research section will have a floor area of 44 ft. by 28 ft. Adjacent to this, a room (12 ft. by 17 ft.) will be devoted to fineness, turbidimeter, and air-permeability tests. This room will be kept at a temperature of 75 deg. F. and 50 per cent. relative humidity. A preparation laboratory (14 ft. by 18 ft. in area) will contain small grinding apparatus, a ball mill, and a small crusher. There will also be a chemical storage room 10 ft. by 17 ft. In addition, there will be three smaller laboratories, one (22 ft. by 14 ft.) to be devoted to alkali analysis determinations, one (13 ft. by 22 ft.) used as an

organic analysis laboratory, and one (15 ft. by 22 ft.) for spectroscopic determination and analysis. The main chemical laboratory will be equipped with chemical benches, steam baths, furnace, compressed-air jets and vacuum lines, and will adjoin a balance room. The second floor will also contain a library. The penthouse will be used for air-conditioning equipment.

The eastern section or the one-story auxiliary building will contain a warehouse (100 ft. by 55 ft.) for the storage of 25,000 concrete specimens in the long-time study. The central section will have one room, 100 ft. by 36 ft. by 32 ft. high for laboratory studies of industrial processes. This will contain storage bins, a tube mill, a jaw crusher, an autoclave, sintering equipment, and an air separator. There will also be a 2-tons and a 10-tons crane. Rooms adjacent to the central section will contain the heating plant and a room (43 ft. by 60 ft.) for crushing and grading aggregates. There will also be two small aggregate crushers, rotary screens, and a dryer. A space of 600 sq. ft. in this section has been reserved for soil processing work.

Trends in Cement Manufacture in the United States.

TRENDS in the manufacture of Portland cement in America are reviewed by Mr. B. Nordberg in a recent number of "Rock Products." There is, he states, a tendency to use kilns from 300 ft. to 400 ft. in length, to control more accurately the composition of the raw material, and to increase the capacity of the grinding equipment. Greater cleanliness in cement works and consequently more agreeable working conditions are apparent. Many packing sheds are being reconstructed. The speeds of kilns are increasing to 75 to 80 revolutions per hour. There are a few instances of kilns running at 100 r.p.h. but with smaller inclinations, say, $\frac{7}{16}$ in. in 1 ft., and thinner beds of clinker. Air-quenching clinker coolers are being installed to facilitate the handling and grinding of the clinker, to provide preheated secondary air, and to fix the magnesia in the glassy state to reduce delayed expansion. Single-stage closed-circuit grinding, with hydraulic classifiers and thickeners, and two-stage grinding, sometimes with crushers through which the clinker is passed before being ground, are common. The two-stage process seems to be preferred in new works. The aim is to produce a graded cement without considerable deficiency in the small grains, the presence of extremely fine particles being considered desirable by some.

Cement Production in the United States.

IT is reported that the total production of Portland cement in the United States in the year 1947 was 31,200,000 tons. The quantity exported was three million tons.

Methods of Measuring Fineness.

THE measurement of the fineness of finely ground Portland cement by determining the superficial area of a unit weight of the cement is now common, and many apparatuses have been designed for this purpose.

The American specification for rapid-hardening Portland cement requires the use of the Wagner turbidimeter and, although air elutriators based on the design of Pearson have been in commercial use in Britain for many years, it was not until the publication in 1947 of the revised specification for ordinary and rapid-hardening Portland cement and the new specification for low-heat Portland cement that British standards included any apparatus other than sieves. The permeability

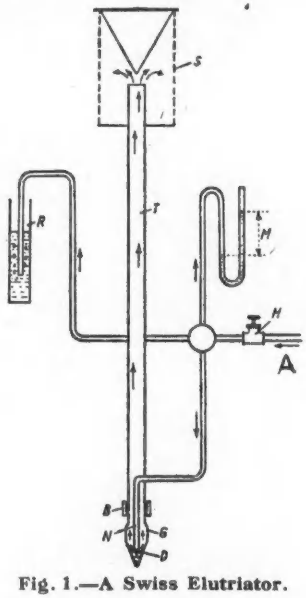


Fig. 1.—A Swiss Elutriator.

apparatus with a manometer and a flowmeter specified in B.S. No. 12 (1947) and in B.S. No. 1370 (1947) is described in our number for March, 1948. Some apparatus used on the Continent are described in the following.

A Swiss Elutriator.

A "flourometer" used in Switzerland is described in recent Swiss and Spanish technical journals by M. F. Guye, head of the testing laboratory of the Holderbank-Wildegg firm of cement manufacturers. This apparatus (see *Fig.* 1, reproduced from "Revista de Obras Publicas") consists of a supply of compressed air (*A*) regulated by a valve (*H*) and maintained at constant pressure by the end of the tube being inserted in the water contained in the vessel (*R*). Consequently, when the pressure exceeds that of the head of water, air is expelled in the form of

bubbles. In addition there is a manometer (*M*) by which the exact pressure is determined. The other exit for the air is through a small orifice (*D*) of 2 mm. diameter in the centre of a glass chamber (*G*) the lower part of which is conical. A small quantity of cement is placed in this chamber. Particles finer than 30 microns are carried up the tube (*T*) by the current of air which passes through the filter (*S*). To prevent cement flour from adhering to the tube, the inside of the tube is polished and a small electrically operated hammer subjects the tube to blows. This instrument is a modification of an apparatus devised by Pearson and Sligh.

The amount of cement used in a test is about 5 gm. and the test continues for 25 minutes. The determination applies to only one size of particle depending on the velocity of the air, the size being the division between the sizes of particles that remain in the apparatus and the size of those carried off by the current of air. The percentage of particles of any other size x is obtained from $R = 100e^{-bx^n}$, where R is the amount of particles greater than x, e is the base of natural logarithms, x is the diameter of the particles in micras, and b and n are constants relating to the material.

Turbidimeters in Luxembourg.

Two types of apparatuses are described in "Revue des Materiaux de Construction et de Travaux Publics, Edition C," October 1947, by M. Andrien Dubuisson, the head of the laboratory of the Société des Ciments, Luxembourg.

A simple optical apparatus devised by Elsner von Gronow is said to be useful only if a single material is being examined. The principle is that the difference in the amounts of light passing through a clear liquid and through the same liquid containing material in suspension is a measure of the superficial area of the particles in suspension. The amounts of light are measured with the aid of a photo-electric cell and the apparatus is calibrated by means of tests on an air-separation apparatus such as the Gonnel apparatus.

The Gronow apparatus consists of a source of light giving parallel rays in the path of which lies the photo-electric cell. Between the cell and the source of light a pair of watch-glasses is placed alternately in the field of the rays. One of the glasses contains a mixture of petrol and castor-oil. The other contains the same quantity of this mixture in which the specimen of the cement has been dispersed. The photo-electric cell is connected to a milli-ammeter and an adjustable resistance of 785 ohms. The scale of the galvanometer, which can be easily read to half a division in 100, is set by adjusting the resistance to 100 when the light is passing through the clear liquid. The reading on the scale when the liquid containing 30 mg. of the dispersed cement is placed in the apparatus can be converted directly into a measure of the specific area, in square centimetres per gramme, by reference to a table prepared for the type of cement being tested. For example, with one cement, galvanometer reading of 40 and 60 may indicate specific surfaces of 2,130 sq. cm. and 1,190 sq. cm. per gramme respectively, while for another cement these readings may indicate 1,870 cm. and 1,040 cm. per gramme.

Fig. 2 shows the arrangement of a newer form of turbidimeter, which can also be used as a colorimeter or as a reflectometer, the various parts of which are: (1) regulator for the resistance; (6) and (9) photo-electric cells *A* and *B* respectively; (10) a switch and (11) the galvanometer; (2) and (3) are a 6-volt 3-watt lamp and a lens giving parallel rays of light which can be directed vertically downwards

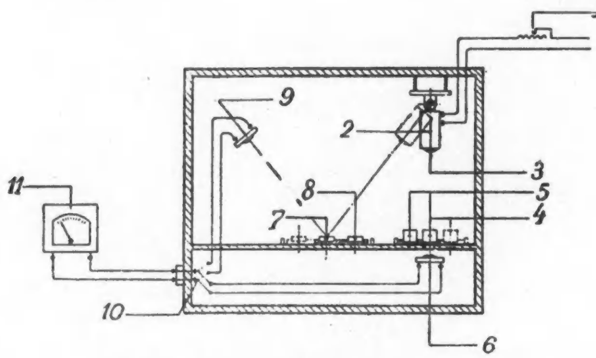


Fig. 2.—Apparatus Used in Luxembourg.

or at an agle of 45 deg.; (4) and (7) are watch-glasses; (5) is a watch-glass containing material in suspension; (8) is a watch glass containing the specimen to be tested.

The resistance is adjusted so that the light falling on the photo-electric cell gives a reading of 100 on the galvanometer, and the apparatus is calibrated with the aid of a Gonnel apparatus, as described for the first type of turbidimeter, and a first-degree curve is plotted to connect the difference in the illumination falling on the photo-electric cell and the specific surface. This curve has at no specific surface a negative ordinate (*C*), which is a characteristic of the liquid, which is a mixture of petrol and castor-oil as before. The ordinate (*C*) at the origin is determined by comparing the intensity of illumination on cell (*A*) when the rays pass through an empty watch-glass and one containing the solution with the material in suspension.

The quantity of material in suspension depends only on the opacity and is given by $14 + 0{\cdot}0455\ K^2$, where *K*, which may have any value up to about 60, is the coefficient of opacity obtained by using the apparatus as a reflectometer, that is with the light falling on cell (*B*). This rule is applicable to cement and many other materials except raw gypsum. The weights for materials having $K = 10$ and $K = 50$ are 19 mg. and 127 mg. respectively.

The method of determining the specific surface by this apparatus is therefore briefly thus: (i) determine the coefficient of opacity; (ii) determine the amount of light absorbed by the liquid to give the ordinate at the origin (*C*); (iii) place in suspension in the liquid the weight of cement determined from the foregoing

expression; and (iv) determine the difference in the quantity (Q) of light absorbed by the specimen in suspension. The specific surface in square centrimetres per gramme is 25 ($Q+C$). It is claimed that for various plasters, blastfurnace slag, various types of Portland cement, and crushed coal the results obtained from this apparatus are in close agreement with those obtained by the Gonnel air-separator, but that the test can be made in a few minutes.

Magnesia in Cement.

WE have received the following from Sr. M. A. Teixeira de Castro, of Sao Paulo, Brazil, with reference to the note on page 67 of the May number of this journal.

"The Czechoslovakian specification is the second specification that permits a magnesia content of 6 per cent. in Portland cement, the first being the Brazilian specification approved in 1937 by the National Laboratories for Testing Materials and later promulgated by the Brazilian Association of Technical Standards under the designation EB-I. Many countries, including Bulgaria, Germany, Spain, Austria, Estonia, Holland, Hungary, Yugoslavia, Latvia, Roumania, Sweden, and the United States, have set a limit of 5 per cent. for magnesia in ordinary Portland cement. Cement has been made in Brazil for twenty-two years and used for all kinds of construction, including marine and fresh water work and work below ground, and the behaviour of the concrete is excellent, no trace of unsoundness being disclosed so far.

"The thermal process in forming clinker and the subsequent cooling are responsible, to a certain extent, for the ultimate properties of the cement. Although there has been a tendency to favour the air-quenching treatment, a large part of the clinker made in Brazil is passed through coolers of the ordinary rotary type.

"Conditions in practice may not be always easily obtainable on an experimental scale, so that the results are not always comparable. It takes some time to standardise new methods, because they are first subjected to criticism and discussion and also their producibility must be confirmed. This applies particularly to the Wagner turbidimeter test (which is still a tentative or recommended method) used to determine the surface area (as may optionally be called for) of high-early-strength Portland cement.

"The Portland cement industry of Brazil started with an output of 13,000 metric tons in 1926. Last year the total output was 900,000 metric tons which was 72 per cent. of the consumption, 340,000 metric tons being imported. Of the ten works now in operation, four are being enlarged to bring the total capacity up to 1,300,000 tons, and three more factories are now planned or under construction. The total annual capacity will be raised to 1,500,000 tons in a few years' time. The consumption of cement in Brazil is now 20 kg. per head of population.

"On page 63 of the same number it is stated that in the new Brazilian specification the amount of manganese oxide must not exceed 6 per cent. in ordinary Portland cement and 5 per cent. in rapid-hardening Portland cement; this should read magnesium oxide."

Technical Advances in Cement Burning.

FACTORS affecting technical advances in the burning of cement are considered by M. J. Hendrickx in a series of articles in "Revue des Materiaux de Construction," a summary of which is given in "Building Science Abstracts," October, 1947. Three factors affecting the efficient and economical clinkering of mixtures for Portland cement are the chemical composition of the mixture, the physico-chemical state of its constituents, and the intensity and duration of burning.

M. Hendrickx's formula for proportioning the chemical composition of raw mixtures according to the silica modulus and taking into account the insoluble silica and free lime, Mr. Bogue's formula based on the compounds, and the formula of Dr. Lea and Dr. Parker based on the saturation factor, are shown to be in agreement when minor variations are made to each of the three formulæ. Particular reference is made to the distribution of the lime, available after satisfying the calcium-aluminoferrite molecule, on the ultimate C_3S and C_2S contents in the clinker as evaluated by each of the three formulæ. M. Hendrickx claims that his formula not only controls the chemical composition of the mixture but also regulates its clinkering properties, especially if it is supplemented by his "burning-type" test.

The physico-chemical state of the raw mixture is considered from three aspects, namely: (1) The mechanical homogeneity, which is characterised by a constant chemical composition and the uniform grading of large batches, and which depends on efficient proportioning of the slurry and the fineness of grinding, and which should be obtainable by precise laboratory control of the carbonate content and the fineness modulus. (2) The macroscopic homogeneity, as characterised by the relative amounts passing and retained on a sieve with 4,900 meshes to the square inch; the amount passing this sieve is termed the "homogeneous mass." It is explained how, as indicated by Dr. Lea and Dr. Desch, the coarse residue somewhat retards and modifies the main burning process. The fundamental composition of the clinker is considered to be controlled by the composition of the homogeneous mass of the mixture and not by its average composition. The suitability of a mixture for burning is determined by the lime content of its homogeneous mass and not by the average lime content of the whole. Methods of determining the lime content of the homogeneous mass from knowledge of sieve residues, and the lime content of the whole mixture and of the residue, are indicated. (3) The microscopic homogeneity, as exemplified by the intimate nature of the raw materials, is shown to have an important influence on the reactions occurring at low or medium temperatures in the preheating zones. The practical significance of chemically homogeneous mixtures, such as those whose constituents closely approach the molecular state, is illustrated by reference to the residual muds from Dr. Seailles's process of alumina extraction. The chemical homogeneity of the limestone in raw mixtures is shown to depend on its hardness, its crystal form (aragonite being more reactive than calcite), and the degree to which the decarbonation can be completed at the lower temperatures so as to obtain a lighter and more

reactive lime. Reference is made to other research on the reactivity between lime and silica and the other constituents, particularly at temperatures from 500 deg. to 915 deg. C.; at the higher temperature about 59 per cent. of the lime recombines with the constituents of the clay.

In considering the effect of conditions of heating and the intimate nature of the silica component of the mixture, it is shown that sand added to low-silica mixtures should be finely ground to increase reactivity, which is also promoted by the formation during the preliminary burning of the more porous tridymite phase. It has been shown by others that the reactivity of the alumina and aluminosilicates depends mainly on the endothermic and exothermic reactions during clinkering, on the dominant type of the hydrate, and on the strength of the bond between the silica and alumina in the silicate molecule. M. Hendrickx is developing a single test which will take into account all the controlling factors.

Some Tests of Pozzolana Cement.

In a report in a recent number of "Revista de Obras Publicas," Mr. M. Pintor describes some tests made with cements mixed with pozzolana obtained in Teneriffe.

The strength of 1 : 3 mortar specimens made with pozzolana cement were compared with that of similar specimens made with ordinary Portland cement, and it was found that the tensile strengths at 7 days and 28 days were 94 per cent. and 99 per cent. respectively of those of specimens without pozzolana. The corresponding figures for the compressive strengths were 82 per cent. and 92 per cent. The tensile-test specimens contained 72.5 parts of pozzolana and 100 parts of Portland cement, and the compression-test specimens 27.5 parts and 100 parts of these respective materials. These proportions were determined by tests to be the most suitable.

Other specimens were submerged in a bath of a 10 per cent. solution of magnesium sulphate. After two years no effects were observed. In Teneriffe concrete blocks made with pozzolana cement are used for sea-walls, and the economy is considerable compared with the use of Portland cement alone.

Tests were also made with mortars prepared from mixtures of lime and pozzolana. The following compressive strengths were obtained at 12 months; the proportions (by weight) are sand : lime : pozzolana: Specimens cured in air.—12 : 4 : 0, 668 lb. per square inch; 12 : 1 : 3, 1,593 lb. per square inch. Specimens cured in water.—12 : 4 : 0, 1,479 lb. per square inch; 12 : 1 : 3, 2,560 lb. per square inch. An analysis of pozzolana from Teneriffe gives total silica 58.14 per cent., combined water 5.82 per cent., alumina 19.27 per cent., sulphuric acid 0.12 per cent., magnesia 1.31 per cent., and lime 1.12 per cent. An indication of the activity of a pozzolana is given by the amount of silica and alumina soluble in alkali. In most pozzolanas the amount is less than 40 per cent., but is about 50 per cent. for pozzolana from Teneriffe.

The Cement Industry Abroad.

India.

DURING the recent session of the Indian Constituent Assembly (Legislative), the Minister of Industry and Supply stated that the present requirements of cement in India are about three million tons a year. The capacity is 2,075,000 tons a year. Information about the output during the years 1939 to 1947 is not available, but the cement factories are not all producing to their greatest capacity owing to transport difficulties, inadequate supplies of coal, and labour unrest. The Government of India intends to increase production up to the existing capacity of the industry and to install additional plant.

The existing cement works are the following (the figures in parenthesis are the daily output in tons): Kymore (834); Khalari (334); Chaibassa (334); Dalmainagar (334); Sone Valley (500); Kalyanpur (666); Jahajha (40); Kistana (266); Madukarai (600); Dalmiapuram (234); Andhra (100); Dwarka (600); Lakheri (750); Banmor (200); Shahbal (666); Dalmia Dadri (133); Bhadravati (66); Surajpur (333); Porbandar (140). The total daily production is thus 6,916 tons.

The following concerns have applied for licences for the erection of new works (in parenthesis are given the position of the proposed works and the annual capacity in tons): Associated Cement Co. (Bihar 100,000; Patiala State 100,000; Bombay 100,000; Bombay 100,000; Madras 100,000; Assam 100,000; Porbandar 100,000; Madras 100,000); Dalmia Cement Co. (Madras 150,000; Bihar 150,000); Shri Digviejay Cement Co. (Jamnagar 100,000); Andra Cement Co. (Madras 70,000); India Cement Ltd. (Madras 100,000); R.B. Shesha Reddi (Madras 50,000); Mysore Iron and Steel Works (Mysore 30,000); Travancore Cement Co. (Travancore 50,000); J. B. Srivastava & Sons (Bhopal 100,000); Bird & Co. (Gangpur State 100,000); Sirmur Traders (Sirmur State 100,000); National Cement, Mines and Industries, Ltd. (U.P. 100,000); C.C. Mankiwalla (Bombay 100,000); Deccan Cement Co. (Bombay 100,000); Mr. Christensen (Bombay 100,000); New Hindustan Cement Co. (C.P. 100,000); Tehri Garhwal State (Tehri, Garhwal State 100,000). In addition to the foregoing factories of 100,000 tons capacity have been allotted to Madras and Orissa. The Government is also setting up a factory of 200,000 tons capacity in Bihar (Sindhri).

Further proposals received during the year 1947 for setting up new cement factories and which will be considered later have been put forward by the following (in parenthesis are given the sites of the proposed works and the annual capacity in tons where this is known): Janjira Darbar (Jafarabad 200,000); Bhavnagar Darbar (Bhavnagar State); Shree A. S. Murthy (West and East Godvari, Madras 50,000); Sri. S.S. Natarajan (South Arcot, Madras 30,000); Madras Government (near Thungabdhra, Madras 30,000; near Godvari project, 30,000); New Industrial Enterprise Ltd., Poona (Bombay 100,000); M.N. Dalal (Palanpur State 127,750); Bombay Bihar Limestone and Mineral Co. (Demu, Bihar 100,000); Rewa State (Rewa State 320,000).

Cement Production in Spain.

THE production of Portland cement clinker in Spain in 1947 amounted to nearly 1,700,000 tons, and the sales of Portland cement to a little over 1,700,000 tons. According to statistics published by the Spanish Government the production was about 1½ per cent. less and the sales about 1¾ per cent. more than in 1946. The sales of special cements amounted to about 138,000 tons in 1947 which is about 3 per cent. less than in 1946.

The production of Portland cement was 61¾ per cent. of the productive capacity of 2,750,000 tons. The stocks of clinker were about 136,000 tons at the beginning of 1947 and 140,000 tons at the end of the year; the corresponding stocks of cement were about 70,000 tons and 59,000 tons. Of 31 cement works, 16 had produced more than 50 per cent. of their capacity, and seven more than 75 per cent.

Cement Works in Iraq.

A NEW works for the Iraq Cement Company is now in course of construction on the banks of the river Tigris near Baghdad. The capacity will be 87,000 tons of cement a year. Limestone and clay will be used as raw materials, and production will be by the wet process. The kiln is 275 ft. long by 9 ft. diameter, with enlarged burning and slurry-drying zones, and will be fired with fuel oil. The output of the kiln will be 250 metric tons a day. The raw material grinding mill is 40 ft. long by 8 ft. diameter, and the clinker-grinding mill is 45 ft. long by 8 ft. diameter. The slurry mixer is 66 ft. in diameter. The machinery is being supplied by Messrs. Edgar Allen & Co., Ltd., of Sheffield.

The Cement Industry in Japan.

DURING the years 1935 to 1945, Japan was among the five leading countries in the production of cement, and the capacity of the industry has never been fully utilised; for example, in 1946 production was about 20 per cent. of capacity.

A report by Mr. L. G. Honk, which may be consulted at the Technical Information and Documents Section, Japanese Intelligence Section of the Board of Trade, 38, Cadogan Square, London, S.W.1, states that the demand for cement in Japan is expected to increase, and that the industry can supply the national demand, and an exportable surplus can be developed, if coal, ships and repair materials are made available. Exports of cement to countries outside Japanese influence were 8·3 per cent. of the total production from 1931 to 1940, while total exports were 21·8 per cent.

Most of the Japanese cement factories were designed, built, and for a time operated, by foreign engineers. Between the years 1919 and 1937 ten Japanese firms made 24 rotary kilns, 13 firms made 43 raw grinding mills, and ten firms made 37 finishing grinding mills. Thirty-nine of the 131 rotary kilns in Japan in 1939 have been transferred oversea. Since 1938 the trend has been toward consolidation of ownership into fewer companies. The report deals with the

history, organisation, and methods of production of the principal cement makers in Japan. The capacity of various works is given and the present situation of rotary kilns transferred from their original sites since 1939 is mentioned. Copies of the report are available by arrangement.

Containers for Cement in Bulk.

THE illustration shows a new type of container built by British Railways, Western Region, which is being used to convey cement in bulk from the cement works at Rhoose to Rhayader for the construction of a dam in connection with the extension of the reservoir of the Birmingham Corporation. Seventy-two of these containers have so far been built. Each container holds $3\frac{1}{2}$ tons of cement, and three will

Cement Container Used on British Railways, Western Region.

be carried on one railway wagon. At the top is a hinged lid which is clamped down after the cement has been poured in through a chute. The containers are unloaded by crane and the contents discharged through two hinged doors which form the bottom. A pump could be used to fill and empty the containers if desired. About 80,000 tons of cement are to be conveyed to Rhayader, and it is expected that 1,600,000 cement bags will be saved.

The Cement Industry in Britain

AT the annual general meeting of the Associated Portland Cement Manufacturers, Ltd., held in London in March, the chairman Mr. George F. Earle, mentioned some of the difficulties with which the cement industry in Britain has now to contend.

In November, 1946, he said, the price of cement was reduced and it was hoped that a further reduction would be made in 1947. This, however, was not possible, owing to additional costs which were outside their control. The most serious of these was the effect of the coal crisis and subsequent coal shortage. The Government decided that the extra costs caused by the coal crisis should be borne by industry and not by the consumer, and in May, 1947, the prospects for the year were gloomy. Ample supplies of coal later in the year enabled good outputs to be obtained and, although through the earlier coal shortage 500,000 tons of production were lost, by the end of the year this had been made up and the production in 1947 was 300,000 tons more than in 1946.

The Government, in order to conserve supplies for the home market, severely limited the export of cement. Now large quantities could be exported, and the industry had a target for 1948 of one and a half million tons. They would do everything possible to pass the target ; up to the end of March the industry had been exporting at the rate of 1,600,000 tons a year. They were thankful that export prices helped the average selling price, for the price allowed in the home market was not satisfactory. The home market price for cement, net at works, was now only 52 per cent. higher than before the war, in spite of the cost of labour having risen by 79 per cent., coal by 143 per cent., and steel by 120 per cent.

As anticipated a year ago, the production and sales of the companies' other products had been excellent and had made a substantial contribution to the profits. The reduction in housing and other building would probably prevent any increase in deliveries of such products in the home market this year, and import restrictions in countries to which they exported were likely to affect oversea sales of specialities.

Coal was the largest item in the cost of production and naturally every effort was made to produce with the minimum consumption of coal. Their efforts were hindered by the low quality received. In spite of this they used last year 5½ per cent. less coal in the kilns per ton of cement than in pre-war days, reckoning the coal on a calorific basis. On coal as actually received they were using 1½ per cent. less than before the war in spite of its poor quality. Once again he would refer to the losses suffered through the bad quality of coal. Compared with before the war, the additional ash and moisture transported from the collieries to their works in 1947 was estimated to be 67,000 tons, for which they paid £167,220.

Production per man hour was seriously affected by the coal shortage in the early part of the year, and although the second half of the year was better than before the war, the average for the year was nearly 2 per cent. worse. If they were to be in a position to compete in foreign markets and keep the price of cement at home at a low level, in spite of the increase in cost of materials and labour, it was essential that they do much better than this, but that was not possible unless they had the coal they needed and were able to purchase and instal the

machinery which, but for the war, would now be in their works. Between 1929 and 1938 production per man hour was doubled. While they could not expect to improve at this rate continuously, if it had not been for the war the trend would have continued. They must now make up for lost time.

Since 1939 their prices and profits in the home market had been controlled by the Government. At present there was much talk of limitation of prices and profits. Whether one liked it or not the profit motive was inherent in human nature. Every one knew how incentive was killed if in spite of an increase in efficiency no increased reward was allowed. Given a maximum selling price everyone would strain every nerve to improve efficiency in order to produce at a cost which allowed him to make a profit or to increase his profit. The manufacturer who, under these conditions, made the highest profit, while maintaining quality, was doing service to the country, for in order to do so he must be making more efficient use of his man-power and materials. The speaker hoped that for the good of the nation the Government, where it had to control industry, would procure fair prices rather than limit profits.

At home they did not know which works and extensions they were to be allowed to build. The British Portland Cement Manufacturers, Ltd., had been able to start construction of one new works at Shoreham but, owing to shortage of labour, progress was very slow. As for the other new works and extensions they had planned, they were proceeding with drawings and ordering machinery where they could get licences, but it was quite impossible to say when they would be able to start construction, much less bring the works into operation. The construction of their new research laboratory was in the same position.

In normal times one could make a forecast of the demand, and plan production accordingly. Now, although they were living in a planned economy, they had not sufficient information about the plans to enable them to do this. He could, therefore, express no definite views as to whether the delay in building these works would mean a shortage of cement in the future, but it was probable that it would have this effect in view of the heavy arrears of building.

The earlier Planning Acts caused much work and delay, but soon they would be feeling the full effects of the 1947 Act, and he would like stockholders to appreciate three things which were happening.

The first was that from the July 1, 1948, the Company no longer had the right to regulate the development of its own raw materials consisting of chalk and clay. The value of their freehold chalk and clay lands was seriously depreciated as a result of the Act which had taken away the development values. In respect of this depreciation the Company would have a right to claim for compensation on the sum of £300 million set aside by the Government, but no one could tell what actual compensation would be received. It was generally accepted that the sum set aside by the Government was inadequate to cover the development values of every acre of land and minerals in the country. It would be necessary to obtain the consent of the local authorities for the development of the chalk and clay underlying the freehold surface. That permission would no doubt be granted,

but on condition that the Company paid the state a development charge which must be a capital sum or a royalty. They were, in effect, having to make a forced sale of the right to develop and use their own freehold materials. The difference between this procedure and actual nationalisation appeared to be very small.

The second thing was that it was becoming extremely difficult, and at times impossible, to negotiate the purchase of land needed for their business. The owner naturally wished to sell land suitable for industrial purposes at a fair price, but if they bought agricultural land for industrial use they then would have to pay the unknown, but probably heavy, development charge. They could not therefore economically buy land at a price acceptable to the owner and also pay this charge. The result was that some, and perhaps much, land was at the moment sterilised for development.

The third trouble was that under the Planning Act practically anyone might raise objections to the building or extension of a works. Some objections were well founded and must be met, but some could only be described as frivolous. The preservation of amenities near their works had always been a matter close to his (the speaker's) heart and it was their intention to do everything that was economically possible to make their new works fit in with the countryside and to improve matters around existing works, but the amount of time and money wasted by public enquiries into these matters should not be thrust upon them in these days when it was essential that all their energies should be concentrated on production.

Following their policy of controlling the raw materials used in their products they had purchased the Anchor China Clay Company in Cornwall in order to secure constant supplies of china clay, which was used in the manufacture of white cement, of which considerable quantities were exported. They had purchased the cement works of Mason's Portland Cement Co., Ltd., near Ipswich. These were small and old-fashioned works, although some modernisation had lately been carried out. They were unable to make a profit while selling at the home market price fixed by the Ministry of Works, and were faced with the position that they must either close down or spend a large sum on modernisation. In view of the demand for cement they were unwilling to adopt the former alternative and disinclined to provide further finance. They therefore decided to sell their works. As soon as the necessary consent was obtained, those works would be brought up to date. They were well situated to supply the fair-sized local demand and had excellent raw materials. He believed that when the reconstruction was completed they would have a very efficient small works capable of making a profit at normal selling prices. In the meantime they intended to operate the works at full output, although with their high costs it was probable that there would be little or no profit.

The year 1948 had started well. The group's deliveries to the end of March compared with 1947 and 1946 had increased by 69 per cent. and 73 per cent. respectively, and were a record in their history for the first three months of a year, while their exports compared with the same years were up by 95 per cent. and 54

per cent. In the home market the normal reduction in demand during the winter did not take place owing to the mild weather; this, combined with the effect of the power restrictions on output, left stocks low for the time of the year.

The prospects for the rest of the year could be considered reasonably good, but it was impossible to estimate home demand as that depended entirely on what decisions the Government might make. However, it seemed fairly certain that exports during the year would take all the cement they were able to ship, and it was reasonable to expect the home market to absorb the balance.